DEVELOPMENT STATUS
OF
AFFORDABLE STABILIZED WEAPON SYSTEMS
FOR NAVAL SHIPS

Authors:

- James Ernest
  Naval Surface Weapons Center
- Douglas Jones
  Kollmorgen
  Northampton, MA

BACKGROUND

Early in 1995, NSWC Crane was selected to provide recommendations, installation guidance, and engineering support for weapons being considered for the MK V SOC. This assignment was made by the then program manager of the MK V SOC Program Management Office (PMO) of the Special Operations Command (SOCOM). As part of this assignment and the result of several comparison studies, a recommendation was accepted for two weapon systems that were not part of the normal Naval Special Forces weapon allotments. The first of these systems was the MK44 7.62mm Gatling Gun System and the other a modified version of the Navy's MK38 MOD 0 25mm Machine Gun System (MGS). These were funded for development and integration into the MK V SOC's arsenal as part of the MK V Pre-Planned Product Improvements (P3I) and supplied through OST.

After installation and actual operations, concerns surfaced regarding the combat survivability of the MK V SOC with the MK38 25mm Chain Gun. At this point OST leveraged internal funding to facilitate a demonstration test. The objective of that test was to determine the requirements for a 25mm weapon firing from a moving MK V SOC.

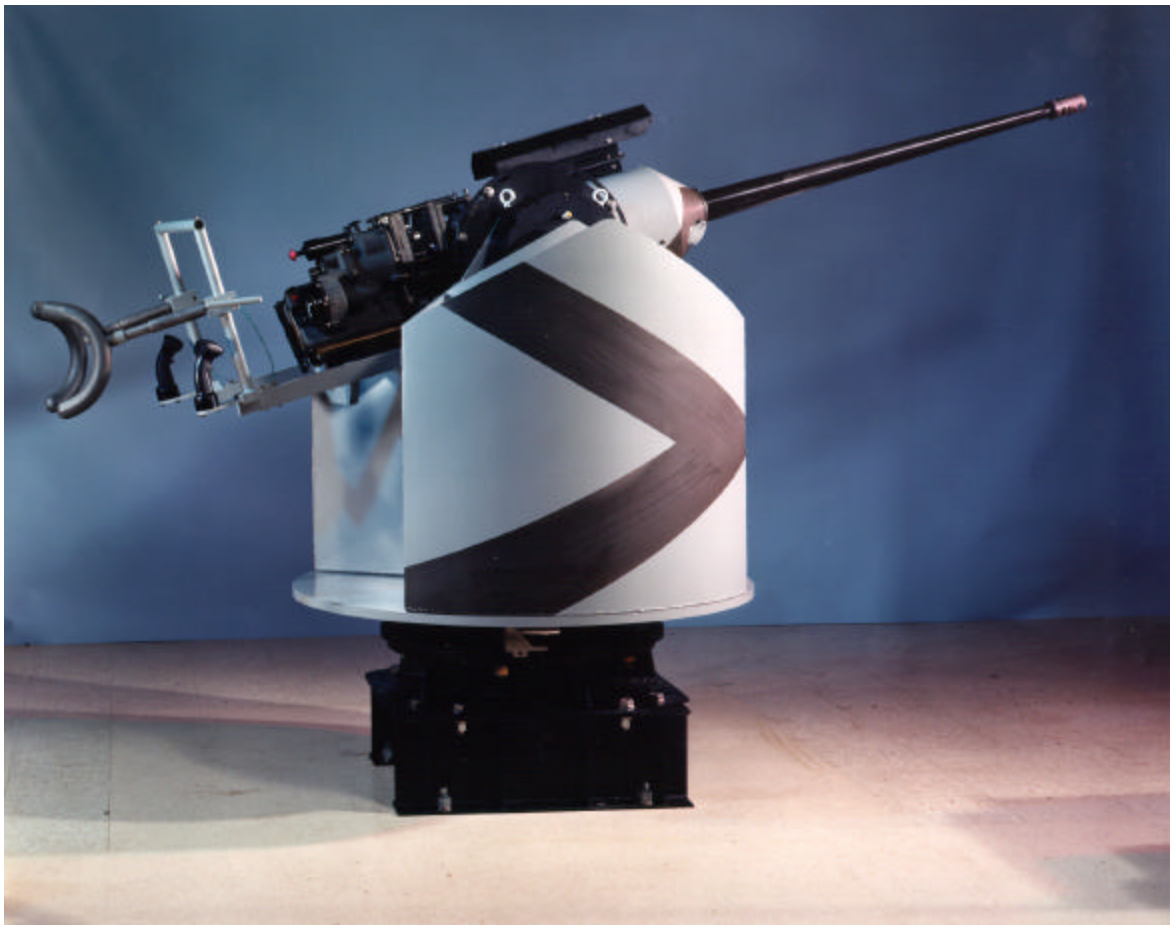
At the conclusion of all evaluations and tests, it was determined that a stabilized and remotely fired 25mm mount, now named the MK98 MOD 0 Universal Gun Mount, was required to provide accurate fire power for the MK V. In January of 1997, OST contracted with Kollmorgen Electro-Optical to develop the stabilization hardware for this mount.

SYSTEM DESCRIPTION: (Both manually operated and stabilized)

Applying cumulative knowledge gained with MK38 design, acquisition and in-service engineering, subjective evaluations of other hardware, and actual testing, the MK98 system developed into the base-line configuration described below. The "framework" manually operated system is identical to the stabilized mount except the choice of the on-mount optical sensor package.

All Kollmorgen hardware and MK98 mount subcomponents have been developed so assembly can be accomplished using normal tools. When not in a stabilized configuration, the mounting locations for the stabilization hardware simply remain vacant and have no structural implication on the mount.

Nomenclature:	MK V SOC 25mm Gun System		
Components:	M242 25mm Automatic Gun MK98 MOD 0 Universal Gun Mount		
Caliber:	NATO Standard 25mm		
Ammunition Types:	M793	TP-T	Target Practice-Tracer
	MK210	HEI-T	High Explosive, Incendiary-Tracer
	PGU32	SAPHEI-T	Semi Armor Piercing, High Explosive, Incendiary-Tracer
Rate of Fire:	Automatic, up to 200 shots per minute Single Shot or other controlled firing rates		
Firing Cycle:	Open bolt clearing, Positive hang-fire, Cook-off safe		



MK98 Mount

Ammunition Capacity:	600 rounds total, split between two containers	
Range:	Maximum	7,200 yards
	Effective	3,000 yards
	Fuse Arming Distance	50 yards (minimum)
Sight:	Day/night uncooled FLIR (8-12 um), 2 FOV, 1 and 3X electronic zoom Day optical camera 1-16X zoom 25mm, 12.5mm and 7.62mm reticles	
Train Limits:	360 degrees, fitted with adjustable stops	
Elevation Limits:	-35 to + 55 degrees, fitted with adjustable stops	
Crew Requirements:	One-man operation One-man loading and maintenance One-man assembly and installation, no material movement equipment required	
Reliability:	1,000 MRBF minimum	
Maintainability:	20 minutes MTTR	
Service Life:	50,000 rounds minimum	

Gun:	Length	Width	Height	Weight
Total	108.0"	12.5"	15.0"	265 lbs.
Barrel	82.5"	3.5"	3.5"	110 lbs.
Feeder	22.5"	12.5"	10.0"	60 lbs.
Receiver	51.0"	9.5"	15.0"	95 lbs.

Mount:	Length	Width	Height	Weight
Total	83.0"	54.0"	58.5"	870 lbs.
Trunnion			41.5"	
Foundation*			6.0"	

* Foundations are supplied with each MK V SOC (3 per craft). Total mount dimensions and trunnion height (barrel centerline) do not include foundation.

System Weight Installed: (mount, sight, weapon)	w/o ammunition	1,135 lbs.

	with 600 rounds	1,915 lbs. (each round weighs 1.3 lbs.)
Recoil Load:	7,000 lbs. peak	
Working Cycle:	74" radius to muzzle break 51" radius to shoulder rest (operator)	
Deck Mounting:	5 bolts on 26.375" diameter	
Power Requirements:	24VDC, 160 amps for gun (800 amp surge currents) 12VDC, 5 amps for sight (10 amp start up current)	

STABILIZATION KIT COMPONENTS: (See Appendix H)

Electronics Unit
Remote Control Unit
Elevation Drive Assembly
Train Drive Assembly

	Length	Width	Height	Weight
Electronics Unit	20.0"	15.75"	27.75"	220 lbs.
Remote Control Unit	33.00	18.60	20.20	165 lbs.
Elevation Drive	18.50	13.50	6.00	150 lbs.
Train Drive	16.25	16.25	15.00	250 lbs.
				785 lbs.

Power:	120VAC single phase, 30 amps maximum
Train and Elevation Velocities:	Variable from .03 to 30 degrees per second.

	EU	RCU
Train and Elevation Acceleration:	60 degrees per second squared	
Pointing Accuracy:	1.0 milliradian, RMS, including closed-loop drift	
Stabilization:	Line of sight stabilization, pitch and roll compensation (2 dimensional) Fiber optic electronic gyros, optical encoders for positional indication PC based operating software utilizing digital logic controls	
Auto-tracking:	Two FOV optical contract tracker Edge or centroidal tracking Offset compensation Manual or Automatic range compensation for aiming	
Sighting System:	Two FOV daytime cameras (1 and 6X magnification)	

ENVIRONMENTAL DESIGN CONDITIONS

Temperature range:	External hardware	-40 degrees F to 120 degrees F
	EU/RCU	32 degrees F to 100 degrees F
Wave slap:	3,000 pounds per square foot	
Shock:	MIL-STD-901, medium weight	
Gun shock load:	30 g's acceleration at 40 hertz	
Vibration:	MIL-STD-162	
Salt Fog/Humidity:	MIL-STD-810	

TEST RESULTS

NSWC Crane, as discussed previously, has conducted or participated in numerous tests aboard a retired MK III PB. This craft is owned by NAVSEA but is operated through the Target Support Group, Aircraft Division, Naval Air Warfare Center at Patuxent River, Maryland. Most of the testing has been done at two designated ranges in the Chesapeake Bay within the operational area of Pax River. For testing the stabilized version of the MK98, a 16 feet by 16 feet stationary billboard-type with an inset target was used. Only hits as evident on the inset target were scored with no consideration

for tracking near misses which are used routinely in analyzing constructive hits against potential recognized threats.

Two different types of tests were used for the evaluation of the system. First, the PB was maneuvered parallel to the target at designated ranges at a constant speed. A finite amount of ammunition was fired at the target. After each pass, the target was physically scored by marking each hole. A second test that more closely matched the MK V operational use of such a system was then conducted. In these scenarios, the PB started at a fixed distance and proceeded directly away from the target. Again, a finite amount of ammunition was fired at the target.

A total of 1,320 rounds of ammunition were fired over the evaluation period with 880 rounds scored. Sea-state on the Chesapeake was 1 to 2 with light winds blowing across the range. Temperature was 45 degrees F. MK III PB test speeds were between 10 to 20 knots. The system operator updated target range data manually.

Constant Range Test:			
500 yards	110 rounds fired	86 hits	78.2%
1,000 yards	110 rounds fired	70 hits	63.6%
1,500 yards	110 rounds fired	38 hits	34.5%
2,000 yards	220 rounds fired	27 hits	12.3%
Variable Range Tests:			
500 - 1,700 yards	330 rounds fired	156 hits	47.3%
Totals:			
500 - 2,000 yards	880 rounds fired	344 hits	39.1%

Subjective testing: 275 rounds were fired during the initial evaluation of the system. For this evaluation, the target was a permanently moored WWII Liberty ship. The interesting part of the test were the prevalent environmental conditions. Professional ethics forbid the direct quotation of the PB's captain, but sea-states were considered a strong 3, with 5 to 7 feet wave peaks that routinely broke over the bow. Wind chill factors resulted in pier side temperatures of 2 degrees F. The mount was used in two configurations. The first was in a manually maneuvered configuration where a single operator fired the mount and physically aimed the weapon. At a distance of 1,000 yards, during 55 rounds of firing, it was noted by NSWC Crane observers that the Liberty ship was hit 5 times. (NOTE: To facilitate counting projectile penetration of the Liberty ship resulted in a bright flash.) The second configuration was with the stabilization activated, firing remote with the system locked into the auto-track mode, and with an offset dialed to the center of the ship. During 220 rounds of firing, no rounds were reported as missing the target. PB speed during this evolution was 15 knots.

CONCLUSION

As a measure of the improved effectiveness of the stabilized MK98 system, the results of this test can be compared to the results of previous OST and Navy endeavors. Below is an attempt to do just that, in which all information listed for the different gun systems are in the "as tested" 25mm configuration. Costs, weights and percentage hits may vary in accordance with changes in each respective configuration.

SYSTEM	TOTAL WEIGHT (POUNDS)	ESTIMATED TOTAL COST ($)	RANGE (YARDS)	% HITS
SSPS Mount 2 w/LRF	4,500	750,000	500	66.0
			1,000	66.0
			1,500	17.0
			2,000	5.0
SSPS Mount 3 w/LRF	2,225	1,300,000	500	69.0
			1,000	56.0
			1,500	27.0
			2,000	20.0
MK 96 w/LRF	3,150	900,000	500	33.2
			1,000	47.2
			1,500	8.2
			2,000	5.3
MK 38 (Man.)	1,380	385,000	500	10.0
			1,000	9.0
			1,500	18.0
			2,000	12.0
MK 98 (Stab.) w/manual range input	1,920	545,000	500	78.2
			1,000	63.6
			1,500	34.5
			2,000	12.3